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PRODUCTION AND PSYCHOLOGY.

Paper presented to the Institution, Grand Hotel, Birmingham, October 24th, 1928. By H. E. Taylor, M.I.Mech.E., M.I.A.E.

THE science of production is a purely theoretical subject, as is, for example, mathematics, the theory being only applicable to actual problems through the agency of man. Whenever the human factor enters into a problem, psychology must of necessity play an important part, and the measure of success which attends any scheme of scientific management will depend upon the extent to which psychology is taken into consideration. The failures which attended early attempts to introduce scientific production methods into Europe have been responsible for much delay in the development of the science and its application in this country. The mistrust aroused by initial failures is, however, being gradually overcome, and the few outstanding successes which have followed the rational application of the science to certain industries have again focussed attention upon its possibilities, and upon the country in which it has proved so phenomenally successful. There is indeed a danger that the pendulum may swing too far the other way, since great harm may result if the reports of various individuals and commissions who have investigated industrial conditions in the U.S.A. are interpreted too literally.

Exact Science and the Human Factor.

Here, however, the initial failures mentioned may serve a useful purpose in tempering the enthusiasm of those who may be tempted to copy blindly the methods obtaining in another country without any real knowledge of production science, and without carefully comparing the conditions and psychologies of the peoples of different countries. Production is now an exact science, and the amount of research work and technical investigations which have been carried out to achieve this end would probably astonish the average individual. The works of Ford and Taylor are well known on account of the spectacular results they obtained, but many other investigators have contributed towards the development of the science. Unfortunately, few people have more than a superficial knowledge of the subject, and the author is of the opinion that the time is now ripe for its inclusion in the curricula of Technical Colleges and Universities.

It is, to-day, possible to determine on paper the exact results which should be obtainable from a new or re-organised factory, and to ascertain what returns may be expected from every pound sterling invested. These results can then be conveniently compared with those already obtained by other concerns. The human factor introduces the only uncertainty into these calculations, and it is a knowledge of human nature which makes the real business leader. A machine or other mechanism can be designed on paper, and provided the designer knows his work the machine can be built and will function precisely as was intended, because psychology does not enter into the matter. In the case of production, however, the complication does exist, and despite the most careful planning and estimation of theoretical results, the whole layout or factory may be a failure if the human factor is given insufficient consideration.

During the whole of his career, which has been devoted to production, the author can state definitely that his difficulties have been concerned wholly with the human side of the problem. Indeed when planning or re-organising a factory, he always considers the study of the applied and administrative labour as being of more importance than the actual planning, and the result of this study decides to a great extent how the introduction of the new methods and systems shall be carried out. It also decides whether the introduction can be rapid, or if the change over must be made gradually to allow time for the applied and administrative labour to assimilate and adapt itself to the new ideas.

(*Here the author showed slides of simple machine units for the production of an automobile gear box, representing the machining section of a mechanical system of production and control invented by him. Under the arrangement all planning is carried out by technical*

men, the machine units being equipped, assembled and maintained by skilled artisans, while the actual production is automatic, The system eliminates the human factor to a large extent and reduces repetition production to its proper level of an automatic mechanical operation.)

The study of man is very complex, and it will be found that although the characteristics necessary for successful production can be arranged in groups, no one individual will possess the attributes of one group only. Further, man's mentality changes at different ages, so that generally it is possible to legislate only for types and not for individuals. Fortunately, human beings are essentially adaptable, and this in the author's opinion is one of the most important reasons why man has attained the dominating position he holds to-day. Under proper leadership and control he can be readily moulded to conform with any system which will ultimately benefit or advance the species. One has but to recall the work of Ford in industrialism or the adaptations of individuals to circumstances during the late war to demonstrate the truth of this statement.

As a whole, applied labour is inarticulate, individually it will grumble and complain no matter how good conditions may be. This is, however, in the author's opinion a very valuable trait and necessary for successful evolution, as it provides an ever present spur to further progress. So long as conditions are good and improving the mass of the people will remain quiescent; should the general trend be static or backward the mass will ultimately revolt. The lead must always come from the technical and controlling classes, whose efforts must be to improve working conditions and accrue an ever-increasing production per unit of population. And this result is only obtainable through the study and application of productive science. A small percentage of agitators and extremists will always exist, but they will only flourish in a country, industry or factory where conditions are backward. It is as well here to point out that as conditions in different countries and industries vary, reasonable consideration must be given to vested interests and the state of trade and politics, and the merits of each case carefully sifted before drastic alterations are attempted.

Industrial Co-operation and the Technician.

Co-operation between the three main divisions, namely capital, and the technical and applied branches of labour, is desirable, but it must be noted that all attempts at a better understanding so far made in England have been between the industrialists and applied labour only. Investigators returning from the U.S.A. speak warmly of the amicable relations between capital and labour there, but in the author's opinion they have overlooked the principal reason for this state of affairs. The condition is not the result of an

initial understanding between the two, but is solely the outcome of the sound scientific management of the technical section, which has made such a state of affairs possible by designing efficient machines and introducing scientific methods which at once further the aims of capital and enable applied labour to produce under good conditions. All the good-will in the world will not create the desired conditions between capital and labour without the intervention of the third member of the trio. In every-day terms, capital, the middle classes, and labour must co-operate, and no two sections can hope for success without the help of the third. Undoubtedly, the future of industry is in the hands of the technical classes and for this reason they should be encouraged and developed by capital. In this way good working conditions for applied labour, and greater profits will be obtained.

One often hears it stated that British and other European technical men do very well in the U.S.A. In the author's opinion this is because we have become naturally mechanically minded by evolution. Mechanical engineering in the modern sense originated in England in the days of the first steam engine, textile machinery and machine tools, and, to-day, a large proportion of the people are born with a natural aptitude for engineering. This natural ability has been developed and applied by the far-sighted controlling classes in the U.S.A., and clever engineers are made specialists in one small branch of productive science, while actual repetition production utilises less mechanically-minded labour. In Europe production programmes are so limited that the few specialists employed are overwhelmed, and one or two men in each concern are expected to carry out the duties which devolve upon a large number of specialists in the case of large firms in the U.S.A.

Three Main Types of Mentality.

There are three main types of mentality in industry.

(1). The controlling or leader type.
(2). The scientific or technical type.
(3). The applied labour type.

As already pointed out, the division is not clearly defined and an individual may combine all three types, but one will predominate. The predominating type may, however, differ at different ages. An industrious youth, intelligent and physically fit, may reasonably hope to pass progressively through the stages enumerated, but unless he be especially gifted in one of them he will not become an outstanding personality. Leaders of industry should so organise technical education that those especially gifted in types (1) and (2) may be distinguished and developed along the particular lines to which they are best adapted.

Not so many years ago applied labour was controlled by a bullying type of man who belonged to the lower end of type (1) scale. Output

was obtained by fear and pressure. Under these conditions individual workers became expert and dexterous, but the ensemble lacked scientific organisation. In a number of cases in this country organisation and planning are still controlled by men of this type. In the author's opinion this is wrong because such work rightly falls within the province of type (2) mentality. Type (2), however, by nature is unsuited for directly controlling workers. The author considers that the line of control in industry should emanate from capital, which represents the best of type (1) mentality. The desires of capital should then be translated by a management having a preponderance of type (1) but which has passed through stages (2) and (3). This will define the policy of control and co-ordinate the various branches such as research, design, production, sales, finance, etc., maintaining the whole in balance.

This policy once defined will be developed by the technical type (2) individuals who will design in co-operation with production specialists, and the production type (2) individuals will plan and organise, but will not directly handle the applied labour. This duty will devolve upon a modified form of works management and foremen who will require to possess varying degrees of type (1) mentality, tempered by a little of types (2) and (3), type (1) however, predominating. Such a system as that outlined does in fact obtain where scientific production is most flourishing.

The ascendency in engineering once held by Great Britain was the result of the exploitation of the inventions of type (2) individuals by the higher type (1), acting through persons lower in the type (1) scale who dominated type (2) giving them little opportunity of expression and development. Our great natural advantages in possessing large supplies of coal and iron also played their part in securing our initial lead in this field. To-day, however, we find that numbers of type (2) individuals are encouraged to emigrate by astute business men in other countries who recognise their potentialities, and develop and utilise them in their system of scientific production. Indeed in the country where scientific production is most advanced a committee on immigration is investigating the distribution of inventiveness on a basis of racial descent. One cannot but admire such foresight, nor grudge the success which is its just reward.

British Empire Resources.

In this country much attention has been paid to the commercial and financial aspects of industry, but too little has been done in the way of technical development and the utilisation of the results of research and invention by rational scientific management and production. An attitude of mind, difficult to explain, until recently existed among our industrialists, and indeed still persists to some extent. This attitude is based upon the idea that because ours

is a small country we cannot hope to compete with the large production programme of the U.S.A. The author's reasoning may be at fault, but he cannot see why the market afforded by a United States of the British Empire should be smaller than that of American manufacturers. Furthermore, we have the inestimable advantages of possessing practically all the raw materials and natural resources required within the Empire. We also control all types and grades of labour and intelligence required for carrying out to its successful conclusion a policy of intensive production. In this respect we are much better situated than the U.S.A. since we control native labour in the countries where many raw materials such as cotton, rubber, etc., are grown, or produced. Surely, then, by paying labour a somewhat higher wage, increasing its productivity by scientific management, and converting the raw materials into goods by scientific production methods, we can produce in large quantities at a price within the, then increased, purchasing power of our dominions, colonies, and protectorates.

Technicians Must be Consulted.

The problem is one to be worked out by our industrialists and politicians, but the technical men must be consulted, and they alone can work out the organisation to a successful conclusion. The author considers that ten years are required for technical education and development along the right lines, and that another ten to twenty years would be sufficient to enable us to regain the lead in industry. Only a few years ago it was considered a hopeless task to try to produce large quantities of automobiles in Europe, and the comparatively large outputs of certain factories, to-day, are due solely to the efforts of a few enthusiasts. How great was the effort required is known only to a few who actually participated in the development, and it is true to say that the results were obtained, not with the help and co-operation of all concerned, but often in the face of apathy and even opposition. Sufficient has now been accomplished to demonstrate the possibilities of scientific production here, but at the same time it is apparent to the author that the influences which stultified development in the past are again at work, and certain people are striving to nullify and retard the work of the pioneers of the application of productive science. It is unfortunate that it is not more fully realised that all types of persons and mentalities go to make up a satisfactory entity, and that there is a place for every type in a well-balanced scheme. If one-half of the energy which is now dissipated in a carefully-camouflaged struggle for position and control, were but directed towards constructive ends, everyone would ultimately be better off than at the present time.

Type (1) is by nature aggressive and possesses a strong personality, both of which are invaluable, and fit the type for leadership.

Type (2) is not aggressive and is incapable of enforcing its aims against the will of type (1). At the same time it is clear that there should be no reason for the conflict which actually exists between the types, since the higher type (2) dislikes leadership and control of men, but does crave for self-expression and the development of its ideas, and is better satisfied by the successful realisation of its ideals than by any monetary reward. Type (3) will be quite content with comfortable working conditions and an improving standard of living and these are readily attainable if types (1) and (2) will co-operate.

An Example of Scientific Production.

A description of the manner in which scientific production was introduced into a certain industry in 1918 may not be out of place. The management in question was young, energetic and anxious to modernise. The applied labour had been gathered together during the latter stages of the war period, and a proportion was in consequence of the "difficult" type. Fortunately a contract for war material was running at the time, and the least amenable labour was transferred to the work, which was segregated, and since it was highly paid piecework the men were glad to be so employed. The remainder of the personnel and plant was to be employed on the production of automobile units, and as the works were new to this type of manufacture there were no traditions to be overcome. The new programme was launched cautiously, and production initially was small. In the very early stages some incentive to effort was necessary as the system was not sufficiently advanced to enforce the production required. The men were therefore offered a graduated bonus up to 50 per cent. on day rates if certain predetermined production figures were obtained. The production demanded, which amounted to some fifty power and transmission units per week, was reasonable in view of the conditions prevailing, and was obtained. The foremen were also paid a bonus and everyone was fairly satisfied.

A certain amount of propaganda was instituted, the firm's intentions of developing the business and continuously increasing the programme and the earnings of the workers also improving working conditions being allowed to circulate judiciously. By this time a reasonably modern layout and organisation for a production of 100 units per week had been built up, and the machines jigged and tooled to an extent which permitted the introduction of straight piecework for the workers, and the payment of an augmented output bonus to the staff. The earnings all round were increased and the feeling of confidence and satisfaction with the firm and responsible officials grew.

The early layouts and details have already been published, so that it is unnecessary to go into the matter again here. Later

developments were comparatively simple, demanding only the rational application of scientific production methods and commonsense principles. In view of the existing atmosphere of confidence, every evidence of increasing expansion was welcomed by the personnel, since the growth of the production programme invariably entailed larger earnings and other advantages. Quite early in the development of the enterprise it was insisted that the introduction of any new machine, equipment or method be accompanied by a genuine increase in the earnings of the man or men concerned, since although the piecework rate was reduced, the increased production made possible more than compensated the workers.

About this time the munition contract ran out, and the men involved, who had watched the development of the automobile business and realised the soundness and justice of the firm's methods, were anxious to participate in the new order of things. They were therefore transferred to automobile work, and with few exceptions became valuable producers. Despite the fact that labour troubles were very prevalent, it is satisfactory to record that the firm suffered from no such troubles, the men remaining loyal and in sympathy with its ideals. This early work provided a firm foundation upon which production programme up to 2,000 per week have been built, and the atmosphere prevailing has permitted the installation of plant and methods far in advance of anything previously attempted. That these satisfactory results were not obtained on account of favourable local conditions is demonstrated by the fact that the same organisation and system has been successfully introduced by the same management in another country. Indeed, although the foreign workers were not acquainted with modern production principles, the introduction was effected more rapidly on account of the confidence gained as a result of previous successes, and because the workers knew that high wages, and better conditions had been the lot of their English confrères.

Psychological Factors.

There are numerous human traits such as conservatism, confidence, courage, fear, sporting instinct, idleness, suspicion, destructiveness, carelessness, cleanliness, mass psychology, and subtle mental reactions, such as emotionalism, superstition, sentimentality and others difficult precisely to define, which must be understood by the successful management. The means by which desirable traits may be cultivated, and undesirable ones suppressed, a good atmosphere being maintained the while, must be studied by the production engineer, who will find that firmness combined with justice will prove more successful than insincere methods. If the fundamental conditions are not at fault the solution of these comparatively petty problems is a simple matter, it is only when the main organisation is wrong that details are distorted from their

correct perspective and trouble ensues. Assuming that it is the genuine desire of industrialists to develop and improve conditions, then, given a constructive policy, combined with a determination to exploit the benefits of scientific production methods and to provide improved means of distribution, much may be done to obviate or mitigate social and industrial crises. It is interesting to speculate as to the future of engineering when scientific production and its attendant psychological and other problems are better understood.

The Future of Engineering.

Engineering is a comparatively new science, and organised production, particularly as applied to engineering, is so new that the possibilities are but vaguely appreciated even by the most advanced production experts. A study of the matter reveals the fact that methods and systems in vogue to-day lag far behind the theoretical knowledge available. It is no exaggeration to say that if productive science in its present stage of development were rationally and adequately applied to engineering fabrication the ft. lb. work output per head of applied labour could be increased several times.

One of the greatest expenses in manufacture to-day is the machine shop, which in the past existed mainly for removing metal which should not be there. The ratio of the weights of rough and finished parts is still much too high, but great progress is being made in the production of more satisfactory castings, forgings, etc. The author is of the opinion that still more rapid developments in the initial treatment of metals may be anticipated, so that only finish machining will be required to prepare parts for assembly. Every engineer realises that a radical change is required in our methods of producing castings, and if this does not materialise it is certain that other methods of initial fabrication, or even a new material will be discovered to take the place of iron castings, and to a lesser extent the other products of the foundry.

Machine tools as we know them to-day will not exist in the future, and the work which they at present perform will be accomplished by machines of two types. The one will be concerned with the preparation of material and will follow along the lines of recent developments in die casting and forging machines, and coining and other presses, for moulding, working, or building metals and materials in the solid, semi-fluid, or liquid states. Certainly plant will be produced of which the present generation of mechanical engineers has no conception. The author believes that it is in these directions that the greatest scope for development in the machine industry lies.

The second part of the plant will be concerned with finishing, and in this direction new discoveries will also be made. The machines will turn out work to a high degree of accuracy and

fitting will be unknown. An operation which will replace grinding will be evolved and will account for the bulk of the work. Machines in the first section of the plant will be very massive, while those in the second will be required to perform light work only, but the tool application will be very intensive. The multi-purpose and special machine will probably not exist, for it will be realised that flexibility is necessary, and the same results can be obtained from simple fundamental units which can be assembled to suit any product. Possibly some development of the author's unit continuous system will be in operation, and certainly the continuous and automatic features will be applied to all branches of manufacture from the raw material, its working, and through all stages of fabrication to assembly and final test, the line being cut only at places which will improve the overall efficiency.

Engineering invention is the greatest factor in the material phase of world development of mankind to-day. and the production and distribution of the results is being facilitated by the very inventions themselves. The intermingling of the people and races of the world brought about by easier communications will exert a great influence on future political and social economy. The future will not be a material competitive age in the same sense as at present, for education and knowledge will ultimately make clear that certain people and races and certain parts of the world can more efficiently produce or do certain things better than others, and the future activities of the world will be balanced and governed by natural and technical considerations and not by artificial man-made limitations.

Unfortunately, we must take the world conditions as we find them to-day and realise we exist in a keenly competitive age and that this competition is necessary as a refining process until we become more enlightened. If we face this fact, it will be obvious that, though a temporary ascendency can be obtained in a given subject by a country producing new, more suitable or better designs, ultimately the business will go to the people who can produce cheapest, or, expressed in technical language, to the people who can produce more ft. lbs. of work per head of the people employed in the given industry.

Therefore, the study and application of efficient production principles and allied matters is one of urgency, for, undoubtedly, its influence will be a controlling factor in world industry in the very near future. In conclusion, the author's opinion is that the policy for this country with its great number of skilled and technical workers is to concentrate on the exploitation of the more recent and advanced inventions in engineering and other industries, and it will be a simple matter to maintain the lead if efficient production methods and what the author calls " Humanics " be studied and increasingly applied.

Discussion.

MR. E. W. FIELD, who presided, said that Mr. Taylor had shown them in his paper how greatly psychological factors influenced the work of engineering. He was interested in the types of whom Mr. Taylor had spoken, and in the question of co-operation Among technicians themselves more co-operation was needed between the designer and the production specialist, as had so often been stressed at their meetings. As a machine tool man, he noted what the author had to say about the machine tool of the future, but in his view it would be purely a development of basic principles as we knew them to-day. Looking back to the lathe of, say, sixty years ago, the modern tool is not such a very great advance—more speeds and feeds, but the basic principle was much the same. In the case of nearly all modern machines they could go right back to the original machines and trace their development. He was a firm believer in the use of simple single-purpose machines. Whether he would agree with Mr. Taylor's special machines he could not say, but he did not think there was a great future for the complicated automatic machine.

MR. W. G. GROOCOCK said that, personally, he was somewhat disappointed. With regard to the human side of industrial problems, psychology, as he understood it, was simply the application of common sense. He was not sure that the author was not right when he suggested the simple unit machine tool, but it must be one that is easily changed and it must be really simple in its application, otherwise it would defeat the end the author had in view. As one who was not in the automobile industry, he felt that the problems of that industry were easy compared with many others. That might be, however, only a psychological reaction on his part! Most machine shop people would agree with Mr. Taylor that the foundry and foundry work had not advanced so rapidly as the rest of industry. Perhaps that was because the foundry had been kept so much in the background.

MR. JOHN FEARN said they could visualise that some day the numerous mechanisms which had been developing during recent decades would be largely standardised. When that was attained the ideas Mr. Taylor had in mind would have a much wider application. Mr. Taylor's work was hastening the arrival of that day, but, meantime, the science of production was an extremely complicated one. He would like Mr. Taylor to explain what he meant by saying that production was now an exact science. He failed to see the exactitude.

MR. E. GREGORY said that he was glad to hear Mr. Taylor stressing the need for realising their responsibilities on the part of management. He had never found much difficulty in persuading the management to buy automatic machines, but it was extremely difficult to persuade

them to buy the tools used on the automatic machines. A man would spend £300 on a machine, but if asked to spend £60 on tool equipment the fat was in the fire. One gave him production times and speeds based on production times, and then, on going round the factory six months later one found the tooling equipment awful. It was not fair to expect rapid production under such circumstances. In connection with the operation of automatic machines, psychological factors had to be taken into account. He had known men whose production was 98 per cent. on a time basis when operating six machines of a certain size, whose production fell to 80 per cent. when transferred to four machines of a slightly larger size. He was glad Mr. Taylor mentioned the fact that often the biggest trouble in management was with the big men. They knew it. It was difficult to balance the heads and the organisation. Perhaps the most successful places were those in which the top man was big enough to hold the rest in his hands.

MR. GARNETT asked Mr. Taylor to tell them the estimated cost of one of the special machines he had illustrated as against equipment planned with standard machines for a given output. When one first saw these machines they rather took one's breath away, but he had followed their development with interest. The standard control unit was now a common practice. Recently he had come into contact with a machine adopting this system similar to what had been shown on the screen that night. The three-way machine, one head vertical and one on each side, had been put down in place of six plain multi-spindle drilling machines and doing work in two minutes which previously took ten minutes, drilling crank cases for small cars. As regards the fully automatic machine, he had heard on reliable authority that Ford was trying to get certain machine tool makers in U.S.A. to provide machines to build the motor car units automatically.

MR. YOUNGASH said it seemed to him that they had got a little mixed between the psychology and the science of production. He was interested in Mr. Taylor's description of his simple units, one or two of which he had seen at work, but how they could be called "simple," passed his understanding. Imagine the feelings of a man who had been working a centre lathe for years confronted with a five-spindle modern automatic! As regards the groups into which Mr. Taylor had divided his types, they seemed to come down, in ordinary terms, to the black coats and the black faces—or, the workers and the drones! It was difficult to make arbitrary divisions. One found, for instance, that men who were by temperament suited for some particular work lacked the education for it. Such men usually became misfits. The psychology of production, so far as he could see, amounted largely to a question of training. They had no methods of training people for executive positions, or even for simple machining operations, yet some machining operations

required preliminary training quite as much as did work in the drawing office. At present they let boys come into the shop, where they ran round and picked up what elementary experience they could; how much better it would be if they were taken in hand and their particular aptitudes found out by a trained observer so that they could be started on the right lines.

Mr. Taylor had mentioned mass psychology. Mass psychology was merely what the everyday man thinks. The average man believed what he wanted to believe and thought in terms of how he saw things. Take the case where a certain machine replaced another one. Mr. Taylor had told them that where this was done care was taken to see that wages under the new conditions were better than previously. That was a condition which one liked to think of in the abstract, but it simply did not work in practice. Ford raised the wages of his workers above those of others and for a time he had the pick of the labour market. But not for long. Other people came up to his line. The result of proper training for young people would be that they would regularly think in terms of doing a job quicker and cheaper, whereas the first thought of the average operative at present was that now he got only five minutes for a job as compared with ten minutes previously. The idea in their minds was one of stark, staring robbery—they used to have ten minutes in which to do a thing and now they only had five. To get a better mental outlook was to a great extent a question of proper training.

Mr. Wright thought that what production really required was a better sorting out of available labour so that people could be put to the kind of work in which their temperament would find contentment. People in Class 1 of Mr. Taylor's grouping were often there for reasons which had nothing to do with their capacity for service. There were many young men in Class 3 who were capable of working efficiently in Class 1 or 2, but the methods in force did not disclose the fact. In his opinion selection should be begun at a much earlier age than the productive age. Elementary education was to blame. In the last two or three years of training at elementary schools records should be kept showing not only general proficiency, but temperamental traits and particular aptitudes, so that it could be said of one that his bent was artistic, of another that his bent was scientific, and so on. Something of the kind was wanted in the schools and in the shops as well, though there was less opportunity in the shops. When a lad came to the latter he was put on a certain job and had to show striking capacity before he was noticed for promotion. They would have to pay a great deal more attention to having the right people on the right job.

Referring to unit machines, which Mr. Garnett had said were doing fairly well, he thought the only field for them at present was in very intensive automobile shops. He thought they must admit

that unit machines were more costly to change over from one job to another than the ordinary single-spindle machines, but considering the amount of work they could do in a short time, there was a distinct advantage in space, labour, and everything else where a reasonable run of a year or so was possible.

MR. A. WEATHERSTONE said that the American definition of an engineer was a man who could control the forces of nature and direct them to useful ends, but Mr. Taylor had shown them in his paper that it was no less important for the engineer to be able to direct human activities on sound psychological lines. Firms like Lever Bros and Cadbury's had put themselves in the front of their own industries mainly by the study of psychological factors. It was by similar attention to psychological factors that their engineering industries would recover prosperity.

MR. E. P. SMITH said it was not easy for the lay mind to distinguish between the psychology of production and individual psychology. To recover their world markets they would have to produce cheaper, and individual psychology would not help them in that. But what would help them very greatly was to study and apply the best psychological methods for obtaining cheaper production.

MR. TAYLOR, replying to the points raised during the discussion, said that Ford's conversion in changing over was the strongest argument for the use of the unit system. If he had had unit machines all his troubles in changing over would have been obviated. Take the unit. In itself it was certainly cheaper than standard machine tools. Mr. Garnet had pointed out that the automatic building of frames was being done in the States. Chassis frames at the Smith plant were being produced automatically, and the only labour is just the tender. Human intelligence was too valuable to throw away on that sort of thing.

Mr. Groocock had referred to psychology and commonsense. As a matter of fact, psychology was the science of mind on the data of consciousness, but this common sense was not being applied. Mr. Fearn had referred to costs. It was possible to give exact figures on what production would cost all round. That was the production man's job. He then gave that figure to the Class 1 man to decide if at the figure the article had a market. For the last ten years he (the author) had given a price guarantee. Mr. Garnett had asked for figures on the cost of unit machinery as compared with standard machinery. To give that would be a breach of confidence, but he could give comparisons. All this machinery when first built was new, but even at that, the contract prices for it were less than half those for standard machinery for the same production, vastly less.

With reference to Mr. Youngash, he believed in training the man. Absolutely. They wanted training and education in connection with this scheme of having the right man on the job. People all

had the idea that boy labour was introduced for cheapness. In his own case it was introduced to get them at the adaptable age, and the boys were paid a high wage so that they could not be said to compete with men. You wanted to teach a boy production, you put him on a simple machine and clever mechanics taught the boy, showed him where he was wasting time, and instilled into him the idea that was wanted. In this way they advanced what would have been labour in a lower position and used the brains of these people. On wages. You could not pay more than a certain sum. If you were going to have big production you must absorb it. The producers were also the absorbers, which he believed was one reason why we had boom periods and depressions. They produced and produced until they had absorbed as far as they could absorb and then the boom stopped. If they produced on low wages they would not absorb. That is one of the troubles they were suffering from in this country at the present time. He agreed with Mr. Wright that the problem was one of education. Mr. Wright had also raised the question of the unit business. In America, with its enormous production of cars, the number of car manufacturers is less than in England, France, or any other country. Production, to be efficient, must be intensive up to a point. In his opinion certain firms in the States had gone beyond the efficient production point. With huge combines the advantage was in sales organisation, etc., but it is not cheap so far as manufacture is concerned. He thought it safe to say that if you reached a production of about 10,000 per week you could manufacture on the cheapest lines, though his own view was that 50,000 was the figure which would reduce costs to the limit of cheapness. As to changing over of units, Mr. Wright thought this was more costly, but he hoped that he had demonstrated that it was not. Mr. Smith had expressed better than he had expressed himself what he was trying to get at. Let them remember that in all this sort of thing they must try to improve the conditions of the human race. All their efforts were getting them further in that direction. He himself thought that this material phase in the evolution of engineering was only in preparation for something else. What had been the result of engineering progress? Before engineering, as they understood it to-day, there had not been much travel or interchange of thought. In the last hundred years the intermingling of thoughts had been great. He believed it was all taking us somewhere—this stage in evolution which they did not understand. It would probably be another twenty or thirty years before this thing was developed. In the meantime it was improving.

On the motion of Mr. H. C. Armitage, seconded by Mr. E. Y. Wiley, a cordial vote of thanks was passed to Mr. Taylor.

DEMONSTRATION OF MACHINERY AND EQUIPMENT AND INVESTIGATION OF PRODUCTION PROBLEMS IN A MODERN PRODUCTION ORGANISATION.

Paper presented to the Institution, London Section, October 24th, 1928. By B. C. Jenkins.

MODERN methods of production have opened up many new and varied phases of activity to the skilled engineer. The organisation has been divided and sub-divided into many specialised branches, all more or less self-contained and circumscribed as regards their sphere of activities, yet entirely interdependent one on the other to maintain the flow of production.

The linking up of the various specialised branches has created a demand for liaison officers capable of understanding and putting forward the requirements of the departments between which they work. The demonstration and investigation staffs act in this capacity between the planning department and production divisions, the work being of a most interesting and diverse character. Demonstration does not, as many people imagine, merely mean the proving of machines or equipment, or the carrying out of some simple mechanical operation. In cases where the proving of equipment is the primary objective, the average skilled operator would be a competent person to carry out such demonstrations. Modern engineering requirements call for men with a much broader experience and of a higher degree of intelligence, capable of understanding and explaining the fundamentals of the problems with which they are called upon to deal.

Demonstration, for the purpose of this paper, may be divided into two main classes, i.e. (*a*) demonstration within the organisation ; (*b*) demonstration by specialists employed by outside suppliers of machinery and equipment.

The reason for, and benefits of, internal demonstration cannot be properly visualised without close study of modern production methods. Production as distinct from design is usually deemed to have commenced when operations on raw materials are started up in the shops. The writer strongly disagrees with this idea and would suggest that production commences immediately the component drawings reach the planning department.

The work carried out by this department is the hub upon which direct production is built and around which it revolves. The more efficient the planning, the less the friction. On the contrary, inefficiency and errors act as powerful brakes. The more intensive the methods of production, the greater becomes the effect of failure to function, as planned, of either machinery or equipment. The

universal type of machine such as our old friends the engine lathe and the universal miller, are being replaced by special-purpose machines designed to give maximum output at minimum cost. Consequently the production foreman has very small chance of carrying-on when failures do occur.

The study of production methods must commence with the planning department, the routine of which is usually on the following lines :

Analysis of component design from production point of view and arranging for the necessary modifications.

Planning of operation sequences.

Analysis of operation sequences to decide necessary machinery and equipment. This may entail drastic revision of operation sequences owing to necessity for using existing machinery or equipment, or due to prohibitive cost of new machinery necessary to carry out the ideal operation sequence.

Estimating the cost of machinery and equipment.

Issuing instructions to the equipment drawing office, authorising design of equipment required.

Estimating production times.

Ordering of new machinery and equipment.

Inspection of new equipment and installation of machinery.

Demonstration of equipment and processes.

It is obvious that much of the work of the planning engineer must be based upon estimates. The writer recently heard an estimate described as an " intelligent guess " and this would appear to be an apt description of many of the estimates the planning engineer is called upon to get out. Accurate estimates and true costs are essential to profitable production. Therefore, all estimates should be based upon the most accurate information available. Guesswork, however intelligent it may be, cannot take the place of practical experience and known facts, particularly if the experience and facts be gathered on a similar product under identical conditions in your own shops. The demonstration and investigation staff should be in a position to supply such information. Let us now consider how this staff can aid the planning engineer.

Analysis of Component Design.

The importance of this function is not stressed as it should be and only in rare instances is it carried out in a proper manner. The modifications asked for are often decided purely with a view to simplification of equipment necessary to carry out the operations. The demonstrator, as the representative of the production side, would be interested in many other points such as the nature of the material and its behaviour when cutting tools are applied. Slight alterations in shape or additional machining lugs would often tend to eliminate the deflection which would otherwise occur. This

tendency to deflect when cutting is one of the most frequent causes of faulty work. Many otherwise excellent sequences of jigs are rendered more or less useless owing to the impossibility of producing flat locating faces on the component to be machined. The amount of material to be removed during machining should be determined at this point and this, together with tolerances allowable, should be shown on the drawings. The even distribution of metal left on for machining purposes would save both time and money and give better results on the finished product. It is up to the planning department to educate the pattern-maker and the die-sinker as to the requirements of production before the patterns or dies are made.

It is useless to design tool layouts on scientific lines with cuts theoretically balanced and then accept castings or stampings which load one tool with one-sixteenth inch cut and another with a half inch. Variations in finished sizes from tools in fixed relative positions are traceable to this source. Ridges and undercuts occur at points where heavy cuts either picking up or leaving off have reacted on other tools.

The amount of draw allowable upon stampings should be indicated, particularly when the job has to be chucked on the taper diameter. In cases where the taper blends into a radius, a smaller radius should be indicated upon the stamping drawing, so preventing an excessively heavy forming cut being taken when producing the finished radius. On work to be produced from bar, the nature of the job should be considered and also the type of machine upon which the job is to be produced. If only the buying department could be made to realise the futility of buying materials on price alone, much time and money would be saved and loss of temper would be avoided. This applies with particular emphasis to bar stock used for producing components on automatic machines. Variations in size, and bent bars "play the deuce."

The writer has seen four-spindle automatic machines fully loaded with only one spindle feeding, all the other bars being jammed in the collets. On other occasions, misfeeding and short-feeding can be seen to occur intermittently on the various spindles. Bright bar with close diameter tolerances should be specified whenever possible and reeled bar when black stock has to be used. Stock should be checked for straightness before issue and badly bent stock should never be issued to automatic machines. The points mentioned above are generally more or less neglected when analysing component design. Many other points of a similar nature would occur when dealing with specific items.

Planning of Operation Sequences.

This section of the planning department activities is probably of more vital importance to production than any other. A badly planned job is like a building with rotten foundations. Replacing

or strengthening the foundations is a most expensive job, only to be undertaken after very careful consideration. The small alteration which appears so simple to make often reacts so badly that the whole edifice is in danger of collapse. The same state of affairs is often found to exist when changes in planning become necessary. It may be that the reversing of two operations would put the production of the job on a sound basis, but this apparently simple change would practically scrap all jigs on the job if carried out. For obvious reasons the alteration will not be made if it can possibly be avoided, consequently the faulty layout is left to stand as a "monument" to someone's inefficiency. Most machine-shop foremen can point out a few such "monuments."

It is a most surprising and annoying fact that in a shop where the general standard of planning is extremely high, one badly planned job is the subject of more adverse and continued criticism than one would hear in other shops which are as full of such "monuments" as a cemetery is of tombstones. Demonstration reports on jobs previously handled should be of great help in planning others of like nature, but no one with progressive ideas would suggest that the planning engineer should continue to follow the same sequence in a slavish manner, however successful the old method may have been. The average man in this position is of a most conservative disposition, slow to change his ideas and methods and distrustful of anything new until its efficiency has been proved in practice. On the other hand one meets the enthusiast for change always prepared to try something new, whether it be machine, tool, jig or operation sequence. Optimistic and often imbued with the spark of genius which most of us lack, his suggestions are usually worth listening to and thinking over. This is the type of man who has done much to bring production methods up to the present high standard of efficiency existing in the modern car shops. In the early stages of his career he usually lacks balance and a sense of proportion. The writer would suggest that no better method of developing these qualities could be found than a course of demonstration and shop investigation.

The training of every planning engineer should include a period on work of this nature, as no other position offers the same opportunity to study the pitfalls over which he is likely to stumble and fall. He can study the work of other men in a fully developed and concrete form and note those obvious errors which were so obscure during the planning and designing processes. The powers of analysis and deduction—without which no one can become a successful planning engineer—must be developed to a high degree when dealing with troublesome jobs in which the effect is obvious and the cause obscure. Copies of all operation sequences should be passed to the demonstration section for criticism and suggestions, it being understood that these suggestions should be made after

consultation with direct production staff where necessary. The interchange of ideas which would be made can be regarded as missionary work of a valuable character to both sides. The finally planned job would be a joint affair, covering different points of view, and the reasoning behind it would be an open book to everyone when about to be put into production.

The value of such co-operation and knowledge can be better appreciated if one considers the many different ways in which the most simple of jobs can be handled. Most of us are apt to think that our method is the one and only correct one, and if any error becomes apparent during demonstration, we are absolutely certain that we should never have " slipped up " in that manner, had we planned the job. In other words, we are wise after the event, and are certainly not in such a knowledgeable frame of mind as we should be if we had taken a share in the actual planning. On the contrary, when errors arise and one is in a state of knowledge as to the reasoning behind the plan, one can more easily trace the point at which such reasoning was faulty and so avoid such errors in future.

Design of Special Equipment.

It is obvious that the planning of operation sequences will to a large extent determine the type and design of special equipment required to carry out such sequences in the most efficient manner. In the organisation with which the writer is associated, the planning engineer responsible for the operation sequence also decides the broad principles upon which all jigs and special tools are to be designed. Nothing can be lost—but much can be gained—by carrying out the same methods of co-operation with regard to equipment design as suggested for operation sequences and the same remarks as to the value of such co-operation apply with greater emphasis.

The detailed design of special equipment should always be the subject of close scrutiny by the demonstration section before any orders for making are issued. Jigs should be carefully checked to see that adequate support has been given to resist pressure of cut and that sufficient clearance is allowed to cover even abnormal variations in castings and stampings. (For some unknown reason most jig draughtsmen attempt to make the jig fit the component like a glove). The method of loading and unloading should be checked, care being taken that spanner sizes are standardised as closely as possible to keep the number of spanners or wrenches down to a minimum. Chip clearance and means of cleaning chips from jig are often found to be inadequate, and whilst being easy to obtain if alteration is made on the board, may be almost unobtainable if alteration is left until the jig is completed. Moving members—particularly spring loaded members—should be protected

from chips and cutting compound, even if it becomes necessary to redesign the jig to obtain such protection. These errors are likely to occur in practically any jig, but are mentioned as an indication of the types of fault which should be detected rapidly by a demonstrator.

Practically all jigs can be sorted into certain well-defined types, each of which has its own peculiarities and liability to error. The new design is usually an adaption of old and well-known principles and in most cases a skilled demonstrator can give valuable advice as to the weaknesses to be guarded against when adapting any given principle to suit a particular component. The design of special tools, and standard tools too for that matter, is of vital interest to production, yet one often finds junior draughtsmen with little or no shop experience engaged on their design.

The writer has frequently heard the remark that any draughtsman of average ability can, by the aid of one or two standard text books, get out a tool layout for any job. This, probably, is the explanation of the fact that so many special tools are discarded in production and replaced by adaptions of standard tools. The designing of good and successful tools requires a deep and intimate knowledge of production processes and machinery. The factors which govern the success or otherwise of a tool layout are so many and varied that even the most experienced of tool designers may be forgiven for an occasional "slip-up." Design of component, rigidity of machine and jig, amount of stock to be removed, feed and speed required, general condition of machine as to adjustment, alignment or wear, and a thousand-and-one other factors all require consideration.

To the junior draughtsman, the number of teeth in a milling cutter—whether it shall be straight toothed, spiral or right and left-hand staggered—are matters of little moment and are often decided by the one he strikes first in a maker's catalogue. The reamer which he orders for, say, phosphor bronze, aluminium and steel, or perhaps a thin tubular section, will probably bear precisely the same characteristics.

The writer would advise every junior draughtsman to study deeply the many variations of the single point lathe tool and its application. Incidentally, many senior draughtsmen and certainly every demonstrator could profitably spend a great deal of time in doing the same thing. Our knowledge of the action of cutting tools on metals is by no means complete, and study of the action of the lathe tool can teach us many valuable lessons. To return to the subject of design of special tools. The demonstrator with the most specialised and local knowledge of the machine upon which the operation is to be performed, should be consulted both before and after the design of such tools. Design of tools should in all cases

follow and never precede the jig, even though it may mean an occasional alteration to jig design.

The Estimation of Production Times.

This work is, of course, carried out by the time study section, all estimates being based on information gathered in conjunction with the demonstration staff.

Ordering of New Machinery.

When possible, all new machines should be inspected before purchase, particularly if such machines happen to be of a type new to the organisation. In these circumstances, it is of great help to the demonstration staff, if machines can be seen in operation and their construction and special features explained by a competent person.

Demonstration of Equipment and Processes.

The actual demonstration of equipment for any operation follows more or less standard lines in any organisation. Jigs and tools are used as planned, the necessary alterations being carried out during trials, until all are functioning in a proper and accurate manner. Exhaustive tests are carried out to determine the most economic feeds and speeds usable on the particular job. Product is checked for accuracy and the job is ready to go into production. It is the policy adopted in carrying out the work which is capable of so many variations. The practice of the organisation with which the writer is connected, is for all jigs to pass a most rigid inspection for accuracy and workmanship before being passed for demonstration. The product of each succeeding jig is carefully checked by the same department and no jigs or tools are allowed to go into production until the product is 100 per cent. satisfactory.

In most cases production does not commence until all jigs in the sequence have been demonstrated and the product passed as satisfactory, the reasoning behind this being that each jig and tool being a unit in the production cycle necessary to produce the finished component, cannot be judged individually, but must await the completion of the cycle before it is safe to say that no alteration is necessary. It would appear at first sight to be an ultra-cautious method, but it has proved in practice to be the one and only method of avoiding vexatious delays due to alterations being found necessary after batches of work have passed the particular operation which required such alteration. When demonstration commences, one soon begins to realise the value of close co-operation with the planning staff. Full information as to all operation sequences and the special equipment appertaining thereto is immediately available and work can commence without the mass of preliminary inquiries which would otherwise be necessary.

The method adopted by the writer when equipment is ready for

demonstration, is for all jigs required for a particular component to be gathered together for a close visual examination, the idea being that each demonstrator can clearly visualise the points of location, methods of clamping, etc. It is important that these points shall be clearly understood as, in many cases, dimensions which are relatively unimportant in the finished component, become of vital importance owing to the method of location for subsequent operations. The component drawing must be closely studied and notes made of any dimensional tolerances which require alteration to avoid trouble and possibly scrap work. It is the rule rather than the exception for large tolerances to be given which cannot be taken advantage of under modern methods of production.

As an example, take a cylinder head. One may find a height tolerance of plus or minus .010 inch, giving a possible maximum variation of .020 inch and a tolerance of plus or minus .005 inch in depth of combustion chamber, which increases the possible variation from the top face to bottom of combustion chamber to .030 inch. The top face is the obvious datum face upon which one locates when producing valve seats, so that without any working variation taking place in the actual operation, depth of valve seatings may vary up to .030 inch, but on reference to the drawing the tolerance allowable may be plus or minus .0025 inch. Again the height tolerance of plus or minus .010 inch may be taken to cover variations in parallelism and such variation may be permissible as far as the component is concerned, but the reaction on jigs locating from different faces may possibly be fatal to essential accuracy in other directions.

The realisation of such points has led the writer to advise that where possible, the same datum face should be used for all machining operations on the piece, except at points where local accuracy is the governing factor. One big advantage of the common datum face is that when relative inaccuracy is found to exist between any two essential points, the operation in which the error exists can be quickly traced and the equipment or process corrected, whereas with constantly changing points of location, all are suspected until the cause of the error is definitely traced, very frequently a most difficult thing to do under such circumstances.

As an instance of the reliability of such methods, we are consistently producing on a fixed spindle drilling machine a bore approximately six inches long relative to two other bores within a tolerance of .002 inch run. Such errors as have arisen having been traced to operative error. After the visual examination has taken place, a component which has previously been marked off, is offered up to the first jig and the necessary alterations, if any, are made to the locating points. This, of course, refers to sequences of jigs in which the first operation is produced from points locating upon the rough casting or stamping. In such circumstances it is the

usual custom to provide rough viewing fixtures with targets to check relationship of all essential machining points. This should, of course, be calibrated with the jig, and no further alteration be allowed to take place on the one without the other. Jigs should now be fitted to the various machines so that the fit of tenons on milling jigs, position of holding down lugs and bolt holes, etc., may be checked, after which the first machining operation may be commenced.

At this point, the procedure as carried out by the writer, is in many cases diametrically opposed to the standard practice. Instead of the demonstrator carrying out the operation with the operator standing by and watching points, the writer prefers to see the demonstrator—after explaining carefully the mechanical details of the jig and the essential points of the job—stand by whilst the operator carries out the operation. This preference is partly for practical and partly for psychological reasons. The primary function of the demonstrator is so effectually to " sell " the equipment to the operator, as to get the maximum output consistent with the required accuracy, in the lowest possible production time. To do this, the relationship between the demonstrator and the operator must be one of perfect amity and goodwill. A spirit of confidence and mutual understanding must be engendered and no attitude of concious superiority must be taken up.

Each operator presents a problem in himself and may possibly require slightly different treatment to get the best results. Every operator, however low he may be graded, is entitled to be regarded as capable of carrying out the work upon which he is engaged in a proficient manner, and few mistakes are made if the demonstrator works upon this assumption. By this statement, the writer does not mean to convey the idea that all operators are proficient, but refers to the attitude which should be taken up by the demonstrator when commencing work. The operator feels that he is being treated as an equal and, in most cases, tries by his actions to prove that he appreciates such treatment and is worthy of it. On the contrary, if the operator is pushed aside contemptuously whilst the demonstrator carries out the operation, he feels that he is being treated as not having even the most elementary knowledge of his job—he has no personal interest in the equipment or process—and probably takes a dislike to the demonstrator which no amount of explanation can eradicate.

Any person with an intimate knowledge of machine-shop practice should realise that although a demonstrator may have a much greater all-round mechanical knowledge both theoretical and practical than the average operator, he is rarely able to operate a particular machine with the same rapidity and facility as the operator who handles it day by day. It may sound peculiar, but no two machines operate alike. Small differences of adjustment, position

in relation to lighting, even slight variations in the contour of the floor upon which one stands, are sufficient to make a marked difference in speed of operation. The operator in constant contact with the machine learns all its little peculiarities and has his own method of allowing for them. Small things, one must agree, but it is the knowledge of such things which forms 90 per cent. of what is termed " operative familiarity."

The value of such familiarity varies largely according to the nature of the work. In some cases it can be said to be almost valueless, as for instance the loading and unloading of chucking automatics, whilst in the case of, say, handling a radial drilling job in which a large variety of shallow holes are drilled and tapped, the value may be equivalent to 30 per cent. to 40 per cent. of the total output.

If the demonstrator is to get the best results from equipment, this familiarity value must be used to its fullest extent, and this can be best achieved by allowing the operator to handle the machine. The operation should be carried out on the first piece with as little interruption as possible on the part of the demonstrator, all errors in the method of operation being carefully noted and afterwards explained in detail, the reason for such changes as may be desirable and their effect, being fully stated. In this way the operator is educated in the finer points and becomes a more valuable asset to the firm. On the other hand, the demonstrator will probably learn something which is of value to himself from time to time. Nine-tenths of the knowledge which a competent demonstrator possesses is gained in this manner, and we all owe a debt of gratitude to the operators. Their mistakes are more often than not our most valuable tutors.

One frequently finds that certain operators are incapable of handling certain classes of work in a satisfactory manner for no apparent reason. Inquiry often elicits the fact that in the past the operator has handled a job of similar nature with disastrous results and consequently, has an absolute dread of dealing with similar work.

Sympathetic explanation of the principles involved and the points to be watched, and a little praise as the points are grasped, will often work wonders in the way of building up confidence. The man treated in this manner becomes a grateful ally and friend of the demonstrator and commences to realise the doctrine upon which all demonstrations should be founded, namely, educative influence.

The writer is firmly of the opinion that the standard practice of the demonstrator carrying out the operation whilst the operator stands by, is practically valueless when handling internal demonstrations. The operator may slavishly copy the movements of the demonstrator whilst being watched, but will almost immediately revert to the method which appeals to him most when left alone.

In other words, the fact that the job has not been explained in a manner which he can understand and appreciate, has left the equipment and process "unsold." It is necessary for a demonstrator to have and hold the respect and confidence of the operators and staff with whom he works, as it is for him to have tools to work with. He must be tactful yet firm, have a keen sense of justice and be as fair to the man as he is to his employer. One cannot expect to get a "square deal" unless prepared to always give the same.

Shop Investigations.

Most production investigations are made by the demonstration staff, as the problems involved almost invariably are connected with jigs, tools or processes. In this connection the aid of a highly organised tool inspection staff is frequently enlisted. In many cases the cause of the trouble could not definitely be determined without such help. The problems dealt with are many and varied, ranging from taps cutting oversize to major troubles which threaten to close down production. The determination of cause and cure of production troubles is a most interesting process, even though it often involves much worry and trouble. One's powers of induction and deduction are exercised to the full and often after the most painstaking investigation, the analysis proves to be fallacious. The writer, when dealing with such problems, uses a process of elimination, gradually throwing out those processes and operations which can have no bearing on the trouble until perhaps two or three items remain, any one of which may be the root cause.

Many minor problems can be rapidly settled by skilful observation. For instance, examination of chips produced by a die or reamer will frequently supply concrete evidence as to cause of trouble. As a matter of fact, chips can tell some very interesting stories to one who has made a study of their characteristics. A book could be written on machine-shop troubles which occur and recur, but it would arouse such painful memories that its sale would be strictly limited.

A typical instance dealt with recently was a rather simple drilling job in which two holes bore a definite relationship one to the other. One hole was drilled in a previous operation and was used as the location for production of the other. The holes were at an angle of 90 degrees and were to house a worm and worm wheel. Centre distance was found to be in error. Jig was checked and found O.K., job set up by a demonstrator, result O.K. Next batch produced centres were wide, the previous complaint being "too close." Examination showed that position of jig under drill spindle was incorrect and that centre distances could be varied from plus to minus by moving jig position, although the jig was of sturdy construction and bushing were of unusual length and in good condition.

Another case was the drilling and reaming of two holes on opposite sides of an aluminium casing, perfect lineability being required. Indexing type of jig was used and errors in lineability were found from time to time, although jig checked up O.K. The error was finally traced to a machine table being out of alignment.

An amusing—though mystifying case to the people concerned, was a long bar job, some 36 inches long, which was produced on a bar lathe. Turning was done by means of roller boxes of excellent design, traverse commencing from collet nose and travelling towards the rear of the machine. First portion of job turned would be round, but gradually a change occurred, until a pronounced hexagon was being produced. Tools of varying shapes and rakes were tried, rollers were replaced and, finally, even the roller boxes were changed with no better result. Error was due to bad shape of bar and consequent bad seating of collet pads. Material was skimmed up for a short length for holding purposes, collets changed, and the trouble disappeared.

These are troubles of the comparatively simple type, but are sufficient to indicate the nature of work called for when dealing with even minor production troubles. Investigation of errors is carried out not only with the object of curing the trouble, but every effort is made to trace definitely the root cause, whether it be machine, tool or method. Upon such findings are based recommendations as to future design of equipment, type of machine most satisfactory for particular operations and changes in process or sequence. The work, if carried out efficiently, gives valuable aid in determining the fundamental principles which form a sound basis for jig and tool design. Investigation of methods and equipment are carried on continuously for the purpose of lowering production costs without at the same time affecting the earnings of operative labour.

Demonstration of Machine Tools.

The demonstration of new machine tools should, wherever possible, be carried out by representatives of the makers. Many different factors enter into the selling of machine tools, but in the writer's opinion, the most successful salesman is a machine installed and got running to the customer's complete satisfaction. Really good machines often get a bad reputation owing to the failure of the makers properly to "sell" the advantages and good points of the machine to the customer and his operators. Men of the right calibre must be detailed to carry out such work,—men capable of explaining every detail in a lucid manner, and who can project their ideas into the minds of those upon whom fall the responsibility for keeping the machine in production. Satisfy the man in the shop that your machine is good by giving freely all information possible. The function of every part of the machine should be

explained, necessity for periodic adjustment pointed out, together with the easiest method of carrying out such adjustments.

If the machine is not automatically lubricated, show the points at which lubrication is necessary. Special features of the machine should be stressed and explanation given of any special attachments which can be fitted, even though they may not have been supplied. Don't be afraid to explain the limitations of the machine—if it is only capable of drilling a two-inch hole in mild steel, say so. You may be able to boost the machine to drill, say, a three-inch hole with one-sixteenth inch feed for a time, but it is bad business to do it. It is much better to tend to understate the case rather than overstate it. Don't forget that the customer who gets more than he expects from a machine is a satisfied man. The demonstrator is an ambassador for his firm and his every action has its reaction. If he is helpful and straightforward in his statements and actions, it tends to enhance the prestige of the firm he represents. On the contrary, slackness and what may be termed in shop slang as "sprucing," will inevitably tend to reflect upon the integrity of his employers.

When proving machine performance, whether the layout be the customer's own design or one supplied by the makers of the machine, care should be taken to see that reports on such performances are eminently fair. Unfair boosting to increase production and lower production time is suicidal. The operators and tool-setters who will be responsible for getting and maintaining production, are expected to maintain the same level of production as demonstrated. Failure to do so means trouble and, before long, the machine becomes heartily disliked, not because it is a bad machine, but simply because it is the cause of the operators' dissatisfaction. This may appear to be a small point, but in fact it is a major one. Operators and tool-setters do have a big say in the success or otherwise of any machine and indirectly may prevent any other machines of that type being installed. Incidentally, the unpopularity of one product of a firm often prevents others being installed.

The main cause of unfair boosting of production times appears to be one for which both suppliers and purchasers are equally to blame. Estimates are asked for and given without a proper inquiry as to the conditions under which production is to be carried out. The purchaser may know that the material he is using is excessively tough, or that stampings or castings have more than the usual amount of material to be removed.

The fullest particulars should be given when asking for estimates of production times. Data relating to the maximum feeds and speeds which have been obtainable and the conditions under which they have been obtained should always be given. Average samples of all castings and stampings should be checked if available, and

their outline sketched out on components blueprints for direct comparison. Any peculiarities of the material should also be given. In cases where components are to be jigged for subsequent operations, points of location should be indicated, together with the tolerances allowable.

In conclusion, the writer would submit that all demonstrations, whether they be handled internally or by an outside contractor, should be based on the firm conviction that a square deal is the one absolutely essential thing. If the goods to be sold are not up to standard, the demonstrator must have the courage of his own convictions and say so. To do this requires courage and grit and often leads to awkward consequences, but the man who will not speak out decidedly lacks the necessary qualifications required by a demonstrator.

Discussion.

Mr. W. E. Gannon speaking with regard to the modifications mentioned by the author, said that these might refer to components or tools. Would the author say which department in the factory should deal with that? It seemed to him that if the technical departments designed a tool very carefully and considered it satisfactory, there would be conflict in the works if another department modified it. At the same time, conflict of opinion was sometimes useful because it brought out different points of view and helped development. As to the demonstration staff, he would like the author to be a little more specific as to how that functioned. When the author spoke of a piece of manufacturing plant or equipment being produced to 100 per cent. efficiency before it was put into production, did he contemplate that when it got into the hands of the skilled operator it might be made to give 120 per cent. or 150 per cent. efficiency, by improvements at the hands of the operator, or was the operator to be told to get on with his business and leave tool design alone? How long would the author recommend that an operator should continue on one job? Did he think it advisable to keep an operator continuously at one job because he was really efficient at it, or did he regard it as advisable to give the operator a change of occupation periodically? Again, when operators were working on some system of payment by results, was it not to be expected that they would turn the work out more quickly than a demonstrator? He rather thought the author had said that the demonstrator should show the operator the pace to work at, but his own experience was that no demonstrator of any new method or new plant could ever produce at the same rate as the actual operators when they got into full swing with the job. He regarded it as a wrong policy for machine makers to send their own demonstrators because these men worked on a demonstration

which was perhaps only 25 per cent. of the time which the ordinary operator would have to work. At the same time they did not produce the same quality of work and very often not the same quantity.

THE AUTHOR said the demonstration staff which he had in mind was a staff in the works always engaged on actual demonstrations or investigations. He had not spoken of a piece of machinery or a component being 100 per cent. efficient, but as being 100 per cent. satisfactory under a rigid inspection. As to modification of design, he did not mean modification of design of jigs and tools, but of the component and he regarded it as only fair that when the planning department or jig and tool designer had to plan and design jigs and tools for a component, they should have something to say as to the possibility or impossibility of producing the thing they were asked to produce. He believed that in many cases the demonstrator could beat the operator although in the majority of cases he could not. In any event, he was able to put up a sufficiently good performance on which to place a time or price for a job. In the Vauxhall factory the practice was for a demonstrator to try out a job and set feeds and speeds and start the operator up. If the operator's work was not considered satisfactory the demonstrator would be called in again and, he had known many cases in which the demonstrator had beaten the operator. The real function of the demonstrator from the machine-tool maker was to show the users the ins and outs of the machine, and prove its capacity to carry out the work for which it was purchased, in a satisfactory manner.

MR. GANNON asked whether the demonstration staff also gave the necessary information to the sectional advisers so that they would be fully acquainted with the new process.

THE AUTHOR repeated what he had said in the paper, namely, that the demonstrator acts in the capacity of liaison officer, by which he meant a source of information for everybody concerned. As to changing operators from one job to another, he agreed that a man should not be kept continually on one operation, because he was very proficient at it. On the contrary, such proficiency proves the man's interest in his work and should tend towards promotion to a better job.

MR. E. W. HANCOCK, in complimenting Mr. B. C. Jenkins on his paper, emphasised the importance of demonstration, not only as a means to mechanical efficiency, but as a very useful intermediary between different departments and between the staff and the operators. He also said that the function of demonstration should be present in all types of factories, large or small, the possibilities of an independent staff resting entirely upon the magnitude of the operation, but the principles of demonstration should certainly be understood by the management. Whilst he agreed that the views of the demonstration staff should be circulated as regards detail

of planning, processing, jig design, etc., he did not agree that a factory should be so organised as to make it necessary for every detail to be reviewed by the demonstration staff, as this would obviously cause considerable delay due to the number of discussions which would emanate from such a procedure. He thought that one of the most important points raised by the author was the value of a demonstrator in maintaining the confidence of the operators, as any business concern which is running on a satisfactory basis is primarily due to the confidence which exists between the human factors throughout the concern. He stated that confidence was the backbone which supported any satisfactory business concern. In connection with trouble investigations, he had always claimed that in this work there was great opportunity to develop the broadness of mind. In a number of the American shops there is a definite staff of men who do nothing else but investigate troubles, and who are referred to there as "Trouble Shooters" and after many discussions with these men, it was clear that their occupation trained them to have broad-minded views, which unquestionably assisted the important function of maintaining confidence throughout the works.

THE AUTHOR agreed as to the importance of the demonstration staff and said that the value of their work could be enhanced by keeping demonstration records. He did not suggest that the demonstrator should have anything to do with the ordering of new machines. All he had suggested was that new machines should be inspected before purchase, not necessarily by the demonstrators. At the same time, where it was possible for a machine to be seen in operation after purchase, the demonstrator should see it in order to gather the points of the machine.

MR. A. BUTLER, Chairman, asked if the chucking of taper diameters on castings was really successful. There were many types of chucks available, but chucking was not the only method of holding a casting. If it were necessary to hold a thing by a taper diameter, to be perfectly Irish, he would say, "do not." He suggested that it might pay to put in an extra operation to turn that particular portion parallel first. With regard to material for automatics, he agreed that whilst the purchasing department should not be allowed to purchase entirely on price, yet price did count for a lot in these days. Many people paid a higher price for bar material in order to get it drawn to fine limits, whereas it could be produced considerably cheaper if a bigger variation could be put up with, because in that event, the dies could be used longer by the manufacturer. He felt that if this matter was taken seriously by the manufacturer of automatics, it should be possible to devise a method which would allow for more variation on the stock and thus enable the stock to be obtained more cheaply. As to modifications of design, his candid opinion was that the planning depart-

ment should have free access to the design office and should be encouraged to point out directions in which a modification of design would facilitate production. There were several very good points in the paper which jig and tool draughtsmen should pay attention to. It was very often found that the jig was a great deal too close to the job. There could be a lot more room and air space round it which, for one thing, would help to get away with the chips more easily. Moreover, it made the jig lighter and more easy to handle. The author had also remarked that spanner sizes should be kept as near standard as possible. Personally, he would prefer not to use a spanner or any loose piece on a jig if it could be avoided. It was something else to take up and put down and get mixed up with the chips and in a good many cases the work could be done by means of cams. The interrupted thread might be incorporated in jigs more than it is—as a check inspection for accuracy in workmanship that was standard practice. It was also stated in the paper that after visual inspection a marked sample was offered to check any alteration, but if the jig inspection was anything like efficient in the first place, it should not be necessary to offer a marked sample. No jig could be properly inspected unless the component was marked out by the inspection department and used for the purpose of checking.

THE AUTHOR agreed with the desirability of avoiding jigging on tapered diameters where possible, but in some cases it was necessary. There was also much in what the Chairman had said with regard to the redesigning of collets which would compensate for different diameters of bar material and he suggested that air-operated collets, with loose pads, might be applied to the automatics, in order to take up the difference in diameters of bars. He did not think that a cheaper material was a cheaper proposition, from the point of view of automatic working, because automatic machines were costly, particularly multi-spindle machines, and it was possible to spend a lot of money in scrap work with bars which caused bad feeding. He had found cam-locking actions unsatisfactory in many cases, because it was particularly hard to get a cam which covered the big variations met with in castings and stampings, but air clamping could be applied in many cases to avoid the use of spanners.

MR. FERGUSON asked whether the shop foreman, who was responsible for output, was consulted before the jigs and tools were sent down to the shop,

THE AUTHOR replied that the shop foreman acted through the demonstrator, because the shop foreman could not be running backwards and forwards between the planning department and talking about jigs and tools. It was the demonstrator who kept the necessary contact between the planning department and the production department.

MR. W. PUCKEY suggested that the author was very lucky if, as

he suggested, he was able to have his jigs, tools and gauges tested and finished before the first operation was issued to the shop. The usual practice was for the first operation to be taking place whilst the other jigs were in the tool room, and he saw no reason why this should not be so. As to the timing of jobs, did the author's firm make it a practice of working out times and then trying to get down to them in the demonstration? Also, with regard to the basis of estimating when demonstrating, what was the practice as regards the grinding of cutting tools? Some people laid down a rule of allowing at least two hours between grinding, but that seemed rather arbitrary, because it depended upon how long it took to reset the tool. How did the author get over this problem? Again, did the author think there was any advantage in having operation drawings?

THE AUTHOR said that times were estimated in the planning department and were frequently based on experiments with similar jobs. In many cases the actual times beat the estimated times, whilst in others the estimated times were not reached. In that case, if it were thought worth while, the jigs or tools would be redesigned, if it were found that the saving would more than outweigh the cost. The time for setting tools and grinding, must be more or less in the nature of an estimate based upon experience. The machines in the firm with which he was associated, were set by tool setters and not by operators, the operators being transferred to other operations meanwhile.

MR. PUCKEY asked what was the actual time taken in changing a tool from one machine to another, because it was impossible to transfer an operator to another machine during that period.

THE AUTHOR said the time for grinding tools was an estimate. He had no experience of operation drawings and, in the paper he was referring to the actual component blue-print drawing. Operation drawings would undoubtedly be very useful but very expensive, particularly with some components on which there were forty or fifty operations.

A VISITOR asked to whom the demonstrators were directly responsible.

THE AUTHOR: To the Superintendent of time study and demonstration and through him to the planning department.

MR. SUMNER asked whether the author thought it would be better to determine the variation in material or to make an allowance beforehand. If the latter, what sort of a standard allowance would he recommend to cover any ordinary variation in material?

THE AUTHOR said that, according to the nature of the work, $2\frac{1}{2}$ to $7\frac{1}{2}$ per cent. would cover contingencies with regard to variations in material.

MR. SUMNER: But would you prefer a standard allowance rather than to make sure by previous tests?

THE AUTHOR: Decidedly, but we must have some experience before we can decide upon a standard allowance. Such allowance must be a variable and the amount determined by the nature of the work.

MR. FERGUSON asked if the operator taking part in the demonstration was compensated in any way for the longer time that might be taken.

THE AUTHOR replied that for that particular period the operator drew day-work pay, even if he were standing still whilst the demonstrator carried out the demonstration.

In the course of further discussion, the author stated that in the majority of cases ample time was allowed by the demonstrator for the operation to be carried out, but after some period the operator was time studied and a time for the operation fixed as a result of the actual experience of the operator. The whole system, however, was based on mutual confidence and the firm would not allow the operators to be imposed upon by the setting of unfair time. His own preference was for the operator to carry out the demostration under the supervision of the demonstrator and by following out this method and, where necessary, fixing the final time after the operator had had a little experience, things worked satisfactorily. As an instance of the mutual confidence existing in the works, he mentioned the case of certain components on which twenty-five or thirty men were engaged in one group. Consistently over a considerable period they earned 30 per cent. above the basis rate, whereas the times were estimated to give the men 50 per cent. bonus. Complaints were made that it was impossible to get more than 30 per cent. As a result, it was agreed to redemonstrate the work and the men agreed loyally to abide by the result whether it was in their favour or against them. The first thing that was done was to split the group up into five groups of five or six men instead of one group of twenty-five or more men, and the result of that demonstration was that 25 per cent. was taken away from the time. When the men got to work, however, it was found that under the new conditions they were earning from 70 to 75 per cent. bonus, which was due to the fact that by working in smaller groups each man was able to help the other much more effectively, so that the final result was that the group as a whole earned extra money. It was the opinion of the author that the small group system was the fairest possible system of piece-work and much more fair than the individual system. The result in this particular case was not obtained by increasing the feeds and speeds in any way, but simply by the fact that the men helped each other much more effectively owing to the smaller number.

MR. JACKSON said that in dealing with what might be called mass production on a small scale, a piece rate was fixed for the operation and if the men did not complain by the time they had completed

50 per cent. of the quantity required, they had to accept the price. If, however, complaints were made, the matter was looked into and adjusted, if necessary. In cases of relatively small batches, however, demonstration would not be possible.

THE AUTHOR said that what happened in a case like that was that the first component put through a jig or series of jigs in actual production really formed the demonstration, whether it was done by a person called a demonstrator or the shop foreman, chargehand or operator. Of course, it would not pay to put on a separate staff of demonstrators in such circumstances.

MR. BROADBENT raised the question of the status of the demonstrator and suggested that it should be at least that of a foreman. An article had appeared in "Machinery" some years ago in which the demonstrator was referred to as a functional foreman.

THE AUTHOR said the demonstrators in the Vauxhall factory had a similar status and, indeed, they were often looked up to by the foremen. At the same time, he thought too much was made of status. Everybody in the works should recognise that they were there for one common purpose and to meet on even terms when there was any question to be discussed.

MR. BROADBENT suggested that this was an ideal state of affairs which did not exist in most shops.

MR. GROOMBRIDGE asked whether there was any bonus system in existence in the country by which earnings were limited in that rates were cut when the men earned beyond a certain amount. There was general consensus of opinion that such methods, although they might have existed years ago and might even exist to-day in one or two old-fashioned shops, had been abandoned and certainly did not exist in modern shops. It was pointed out in the course of some discussion on the matter that up-to-date firms to-day would rather leave a rate on the generous side and leave the men to get on with the work as fast as they could than cut the rate. The general practice, it was emphasised, is to let the men earn as much as they can and not to cut rates unless there has been a definite change in the method of production which made the original rate an unreasonable one from the employer's point of view.

THE CHAIRMAN asked the author how the group system was worked in the Vauxhall factory. Was the bonus spread *pro rata* throughout the group?

THE AUTHOR said that was so. The basis of the system was that for each hour's base time the group received one and a half hours pay. Thus, each four hours' work, produced in the base time, represented six hours' pay spread over the group. As an illustration take a cylinder block on which the base time is, say, ten hours. If ten blocks were produced by a group in one working day, the actual hours credited for payment to the group would be 150 hours. The debit would be the number of hours worked by the group

collectively and the balance would represent the bonus earned. The group bonus system covered many things than an individual piece work system could not cover.

MR. JACKSON said his experience of the group system was that there was not a great deal of brotherly love in the sense that better workers would help less efficient workers. Indeed, his experience was that if one man in the group was thought by the others not to be a sufficiently good worker, they quickly asked for him to be shifted.

THE AUTHOR said that was one of the strongest points in favour of the group system, because it was frequently found that although a man might not be up to the standard of the other men in the group on one operation he was a first-class man to put into another group and might even aid in increasing the output of that other group. In other words it avoids the retention of square pegs in round holes.

MR. FERGUSON asked if there was a system of payment by results in the Vauxhall works for labourers.

THE AUTHOR said that a labourer received group payment when engaged with one particular group or his time was charged proportionately to a number of groups if he were working on more than one. In practice it was found that the labourer would carry out such operations as removing the swarf when the operator was away or when the machine was being set, as in that way he assisted in output and, whilst enabling the operators to earn more money he himself shared in the greater output.

At the conclusion of the discussion a hearty vote of thanks was accorded to the author.